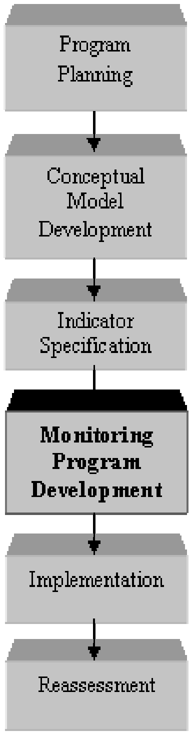
This document contains information on Monitoring Plan Development and Modification, Indicator Implementation, and Indicator Reassessment for the Indicator Development for Estuaries report. EPA-842-B-07-004. The remainder of the document can be downloaded from: http://www.epa.gov/owow/estuaries/indicators/

Indicator Development for Estuaries

February 2008



MONITORING PLAN DEVELOPMENT AND MODIFICATION

The development of monitoring plans has been discussed in detail in other guidance manuals (EPA, 1992). This section highlights the steps discussed elsewhere, describes how monitoring activities fit into the indicator paradigm, and focuses on how ongoing monitoring programs may need to be modified to better address indicator program needs.

EPA's *Monitoring Guidance for the National Estuary Program* (EPA, 1992) specifies five steps for designing a monitoring program (Figure 10):

1. Develop monitoring objectives and performance criteria
2. Establish testable hypotheses and select statistical methods
3. Select analytical methods and alternative sampling designs
4. Evaluate expected monitoring program performance
5. Design and implement a data management plan

The first two steps are somewhat analogous to the processes outlined earlier in this manual for indicator development. The development of management goals for indicators and the indicators themselves can be used as the monitoring objectives and performance criteria for a monitoring program (Step 1). The conceptual models are in essence the basis for formulating testable hypotheses (Step 2). The selection of methods and sampling designs will be driven by available equipment/expertise, regulatory requirements, location of sensitive areas, and local geomorphology, to name a few factors (Step 3). Programmatic indicators will be critical in evaluating monitoring program performance (Step 4). The design and implementation of a data management plan (Step 5) is a key part of any monitoring program, but with regard to indicators, the only connection is the need for the data management schema to be able to record and track data associated with indicators and their calculation.

Many sources of information for developing a monitoring plan from scratch are available, such as EPA's 1992 guidance document and *Managing Troubled Waters* (NRC, 1990). These and other documents lay out the objectives, approach, and detailed examples for monitoring program development. Any new program should take into account current and potential future indicators and include measurements that are both directly and indirectly relevant to the indicators. Not only should the parameters included as part of specific indicators be measured, but also ancillary information pertinent to understanding the conceptual model and information necessary for interpreting trends in the indicators.

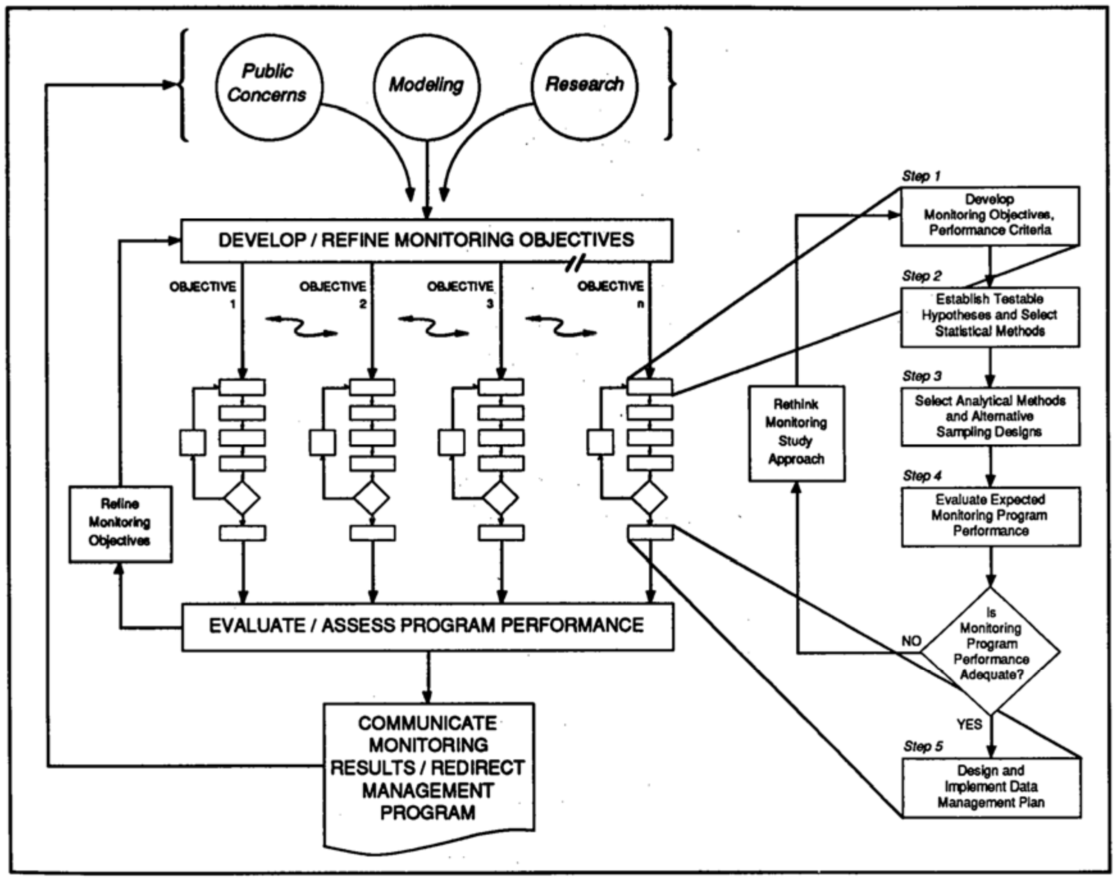


Figure 10. Five Steps in Designing a Monitoring Program (EPA, 1992)

Rather than revisit the steps involved with monitoring plan development, this section focuses on utilizing data from ongoing long-term programs and adapting current monitoring programs as necessary to fit the proposed indicator paradigm. Most groups looking at indicators begin the process by focusing on parameters that are already being monitored. What also needs to occur is a reevaluation of the monitoring plans to make sure the data being collected on the selected indicators are sufficient to answer the question. If not, programs could select indicators that will not address the scientific needs.

The expectation is that there is an existing, clearly defined, long-term monitoring program(s) in place in the area of interest. The first step is to list what variables are currently monitored and identify where, when, and how often they are monitored. Does the list of variables and the spatial and temporal extent of the sampling provide enough information and resolution to feasibly characterize an indicator(s)? If so, move on to the next indicator of choice and run through the same process. If not, decide whether the indicator warrants the cost of enhancing the monitoring program to make the additional measurements needed. At this point in the process, the scientific relevancy and utility of the indicator has already been established, but if the measurements are not made in the existing monitoring program, there may be limited historical data with which to compare.

This lack of data would diminish the overall worth of the indicator in question. If, however, it was still deemed a scientifically necessary component, then the decision comes down to relevance versus costs. Modification of indicators may be a viable and less costly approach when long-term data sets are available, but the necessary data are not available.

In many cases, there will be multiple monitoring programs from which to draw information for indicators. This is especially true for the development of regional indicators. The aspects of coordinating data and efforts across various monitoring programs not only provides a regional context for data and indicators, but also may provide significant cost savings to the agencies or groups currently conducting the monitoring. The steps are similar to the approach for an individual program. The first step is to obtain a list of what is presently monitored by each program. The next is to ensure that comparable methods have been used and that the units are standardized before the data are combined or compared. Whether comparing current data to historical data sets or one monitoring program's data to another, it is necessary to be aware of incongruent data sets. It may be possible to rectify data sets after the fact by conducting interlaboratory comparisons. This is recommended only in cases where different, yet valid, methods have been used. Interlaboratory comparisons are certainly recommended for ongoing monitoring programs to ensure comparability into the future (see the SCCWRP callout box on page 50).

Whether comparing current data to historical data sets or one monitoring program's data to another, it is necessary to beware of incongruent data sets.

Long Island Sound Study—Data Comparison

Two issues arose once the monitoring data were collected for assessment: (1) the monitoring protocols of New York and Connecticut were not consistent, and (2) information was needed on a watershed basis but collected by town and zip code. (Pidot, 2003)

At times, little thought is given to statistical design during the development of monitoring programs. This is often because there is a specific localized focus or interest. For example, water quality monitoring can focus on an outfall for permit compliance or seagrass monitoring at a specific resource location rather than more random coverage encompassing areas of that resource over an entire embayment. EPA's *Monitoring Guidance for the National Estuary Program* (1992), and references therein, provide details on statistical design of monitoring programs. In order to have a robust indicator, the monitoring data used need to appropriately describe the spatial and temporal scales of interest.

There are four basic spatial sampling schemes: random, systematic, stratified, and multistage. A random sampling design locates samples independently at random locations within an area of interest. This type of design is the easiest to implement but

Southern California Coastal Water Research Project—Interlaboratory

SCCWRP was designed “to gather the necessary scientific information so that member agencies can effectively, and cost-efficiently, protect the Southern California marine environment” (SCCWRP, 2005). To characterize the area, several laboratories collect and analyze samples throughout the area; then SCCWRP compiles and compares the data to develop an overall picture of the ecosystem. At the beginning of the SCCWRP process, problems were noted with data inconsistencies. To ensure that the overall assessment of the area was correct, all laboratories submitting data to SCCWRP needed to be processing and analyzing sample in ways that resulted in compatible data. SCCWRP met this challenge by performing intercalibration exercises and in some instances, standardizing methods. The interlaboratory calibration data were used to compare the accuracy of data developed before and after the standardized methods. Prior to standardizing methods, the data ranged 20-fold between the lowest and highest values (top table), while data after standardization were more uniform (bottom table).

Data Prior to Intercalibration and Standardization

SANTA MONICA BAY SEDIMENTS – FIRST ROUND

	COMPOUND	LAB-1	LAB-2	LAB-3	LAB-4	LAB-5LAB-6
Naphthalene	54	171	279	27	139	259
2-Methylnaphthalene	129	485	721	59	405	615
1-Methylnaphthalene	61	172	272	23	181	222
Biphenyl	233	756	1140	97	606	770
2,6-Dimethylnaphthalene	131	217	401	37	228	203
Acenaphthylene	ND	4	ND	ND	ND	ND
Acenaphthene	ND	15	46	ND	ND	ND
2,3,5-Trimethylnaphthalene	ND	19	ND	4	15	ND
Fluorene	ND	38	75	2	24	69
Phenanthrene	ND	137	469	9	109	112
Anthracene	ND	ND	111	13	19	18
1-Methylphenanthrene	ND	154	ND	ND	51	ND
Fluoranthene	76	ND	495	26	87	108
Pyrene	91	ND	1120	28	79	111
Benz[a]anthracene	ND	ND	284	30	65	38
Chrysene	60	ND	320	31	83	46
Benzo[b]fluoranthene	ND	ND	672	19	205	38
Benzo[k]fluoranthene	ND	ND	205	18	77	41
Benzo[e]pyrene	ND	ND	367	11	171	63
Benzo[a]pyrene	ND	ND	409	13	162	ND
Perylene	ND	249	183	5	72	32
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	69	23
Dibenz[a,h]anthracene	ND	ND	ND	ND	ND	38
Benzo[g,h,i]pyrene 12/10/2002-New Hampshire	ND	ND	60	ND	109	30
Total PAHs	835	2420	7630	453	2960	2840

Data After Intercalibration and Standardization

SANTA MONICA BAY SEDIMENTS – FINAL ROUND

COMPOUND	LAB-1	LAB-2	LAB-3	LAB-4	LAB-5	LAB-6
Naphthalene	173	162	170	191	139	193
2-Methylnaphthalene	388	435	480	532	336	525
1-Methylnaphthalene	***	145	185	166	153	144
Biphenyl	650	644	850	800	535	796
2,6-Dimethylnaphthalene	365	212	255	343	214	269
Acenaphthylene	***	8	ND	ND	ND	ND
Acenaphthene	***	ND	25	15	ND	ND
2,3,5-Trimethylnaphthalene	***	22	ND	119	47	ND
Fluorene	ND	25	49	40	39	52
Phenanthrene	114	131	145	130	142	141
Anthracene	***	33	34	58	41	29
1-Methylphenanthrene	ND	62	27	68	73	128
Fluoranthene	183	280	150	135	146	183
Pyrene	211	196	155	230	125	185
Benz[a]anthracene	93	126	145	118	37	114
Chrysene	115	88	120	152	127	145
Benzo[b]fluoranthene	***	164	330	179	60	92
Benzo[k]fluoranthene	***	63	103	167	60	90
Benzo[e]pyrene	117	115	155	183	51	115
Benzo[a]pyrene	94	109	195	191	52	65
Perylene	ND	91	78	110	70	26
Indeno[1,2,3-c,d]pyrene	***	44	ND	ND	88	66
Dibenz[a,h]anthracene	***	26	ND	ND	ND	ND
Benzo[g,h,i]pyrene 12/10/2002-New Hampshire	34	100	ND	ND	80	97
Total PAHs	***	3280	3650	3930	2610	3450

(Weisberg, 2002)

Monitoring Program Development

may not provide the most cost-effective approach or achieve a true understanding of the entire system, as the coverage is random (fine for standard error and other statistics, but not when clear geographic gradients are known *a priori*). A systematic design has sampling locations spread over equal intervals across the region and provides representative coverage of an area. Stratified sampling separates a region into multiple areas and allows for different sampling intensity in each area based on the expected variability or areas of concern. This approach allows for more cost-effective sampling as more resources can be applied to known areas of concern and less in areas that are relatively homogeneous (*e.g.*, many stations in a confined area in the vicinity of an outfall, but fewer in a larger area further offshore). See the *Visual Sampling Plan* (VSP) callout box below for information on a helpful software developed specifically for designing statistically based sampling plans.

Visual Sampling Plan (VSP)

If a program needs help assessing the spatial schemes of sampling the area of interest, free software is available that can help. EPA, in conjunction with the U.S. Department of Energy and U.S. Department of Defense, has developed a program called *Visual Sampling Plan*, which provides “simple, defensible tools for defining an optimal, technically defensible sampling scheme for characterization” (PNNL, 2005). VSP, which can be downloaded from http://dqo.pnl.gov/vsp/, can be used to design a cost-effective monitoring program to meet specific statistical criteria or can be used to evaluate a current monitoring program. One benefit of using VSP to design monitoring programs is that it “provides immediate feedback of the projected results of selected statistical sampling plans by overlaying random sampling locations or grids directly onto the site map” (PNNL, 2005). In addition, it “provides graphic decision tools such as graphs of probability of hot spot detection vs. total sampling costs” (PNNL, 2005). See http://dqo.pnl.gov/vsp/ for more details.

The last strategy described in EPA (1992) is multistage, or tiered, sampling. This applies to both the areas sampled—the first stage might be the entire region, the second stage representative areas within the region, and the third stage specific areas of concern. Not only could sampling be done on one or more of the stages, but also the types of parameters measured could be spread over different stages. This is often the case with monitoring programs. There are many stations where a basic suite of measurements are collected (low effort and low costs), and then a subset where more costly and time-intensive measurements are made. An example of this is provided in Figure 11, which shows the sampling design for the MWRA water quality monitoring program. This multistage sampling design spreads out the parameters measured across multiple stations and also has different frequencies with which stations are sampled. The nearfield stations, which are within a 10-kilometer-square area of concern around the MWRA outfall, are sampled 17 times per year, while the remaining ‘farfield’ stations are visited only 6 times per year.

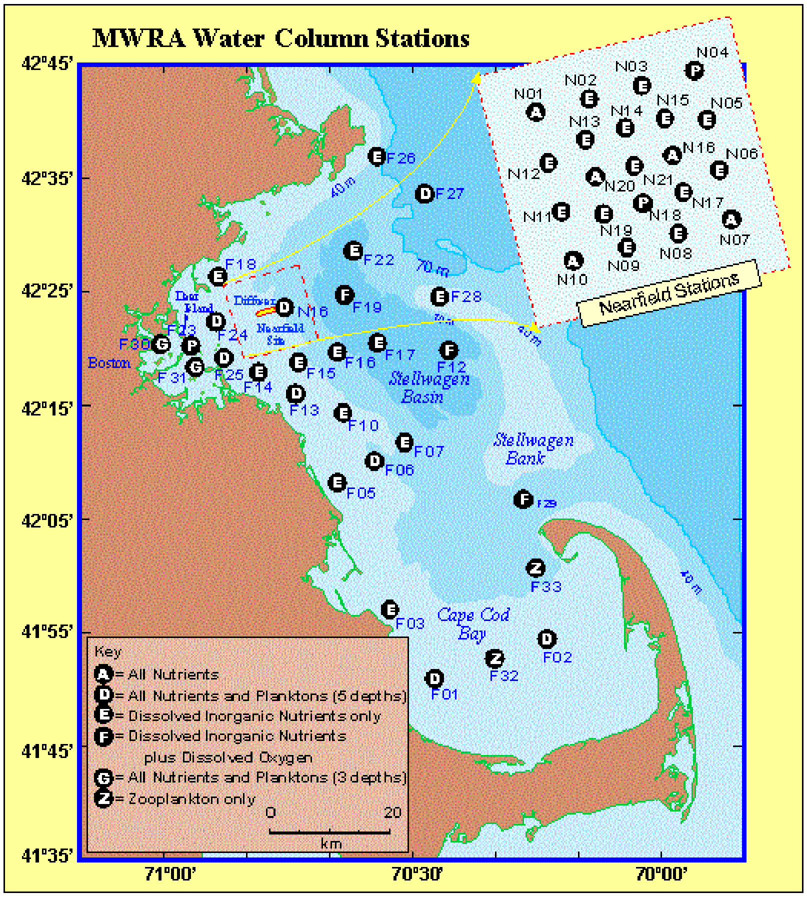
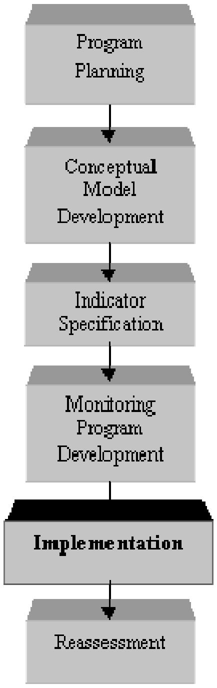


Figure 11. Multistaged or Tiered Sampling Design of the MWRA Water Quality Monitoring Program



INDICATOR IMPLEMENTATION

Once indicators have been selected and a monitoring plan developed, the indicator program needs to be implemented. The process of implementing an indicator program will vary, depending on how many organizations are involved in the process and the overall goals of the program. In some instances, indicator programs are implemented by a group of organizations working toward the same goals; in a few instances, only a single organization is involved. This section focuses on some of the important aspects of implementing an indicator program that involves more than one organization, but several of these steps also apply if only one organization is implementing the program. The steps that will be covered under implementation are:

> The success of indicator development depends on how the program is implemented and involves many steps.

- Formal adoption and funding of the program
- Communication among organizations
- Monitoring plan implementation
- Data collection and analysis plans
- Reporting of indicator findings

FORMAL ADOPTION AND FUNDING

The first step in implementing an indicator program is getting it formally adopted by the organization(s). This means that the organization plans to do its best to implement the program using available funds. Most programs implemented by agencies and groups have been mandated in some way by an act of Congress, through a state legislature, or as part of an agreement with another organization that supplied the funding. Thus, the goals and reasons for conducting the work are set by what the group has been tasked to accomplish. In the NEP, formal acceptance by the management or TAC is required for formal acceptance of indicator implementation. The agreements sometimes include signed Memorandums of Understanding (MOUs), which specify the goals and obligations the groups have agreed to try to reach. MOUs are particularly useful when trying to implement an indicators program that stretches beyond the area of one monitoring group. It allows members of regional programs to have an exact understanding of what they have agreed to when joining the program. It also gives a regional group an understanding of what it should expect from its constituents. Each MOU is written based on the individual programs and groups involved. Either way, the important point is that someone in each organization agrees to seek the funding and staff to implement that organization's portion of the program so that it can deliver the necessary data to reach the end result.

MOUs are particularly useful when trying to implement an indicators program that stretches beyond the area of one monitoring group.

Formal adoption of a program is important, but so is funding. It is unlikely that any single agency or organization will have enough funding to accomplish every task. One goal for many indicator programs is to reduce the amount of money spent by determining whether questions raised for that program have already been answered elsewhere and, if so, obtaining the answers to those questions from those other sources. Programs developing indicators for additional questions should plan to find the funding to cover the new work. Get buy-in on plans from agencies so that they can help fund programs. Try to find other groups that may already be monitoring the parameter and see if data can be shared. Other programs have used the development of a list of indicators to negotiate for additional monitoring funds. Lack of funds for monitoring does not have to be a reason to forgo developing indicators.

Great Lakes Program—Management Involvement

"The interviewees strongly suggest bringing managers into the process early on, both so that the product is as useful to them as possible, and to create a sense of ownership which might increase managerial use." (Pidot, 2003)

COMMUNICATION AMONG ORGANIZATIONS

Communication among all parties within any program is one of the most important aspects of a successful indicators program. Communication must occur in order to develop an appropriate list of indicators, implement the monitoring plans, and report results. Successful programs result because everyone involved knows exactly what needs to be done, when it needs to be accomplished, and who is doing the work. Most importantly, if a problem arises, it is important that it be discussed early on and that all parties work to solve the issue. For instance, if an indicator is selected to monitor a situation, but someone discovers that the indicator is not properly documenting the changes as intended, this should be immediately communicated to the group so that the situation can be evaluated and money is not spent on an indicator that does not work. Another problem that must be communicated is lost or unavailable data. If the program is relying on the data to make a judgment about a portion of the environment, the entire group should be notified that the data are not available or that help is needed in collecting it. It is important that communication occur freely and openly within the program to ensure its success.

Communication among all parties within any program is one of the most important aspects of a successful indicators program.

Communication with stakeholders throughout the area is also important. This includes not only the organizations or agencies involved in the program, but also the public. Programs that demonstrate usefulness and answer questions that environmental managers and the public are interested in tend to get more funding. Therefore, from the beginning of the program, those involved with its development need to sell its usefulness. The group also needs to show timely results. Thus, the results of the indicators program need to be analyzed and reported promptly so that area managers can use the information to make decisions on next steps. Data from a couple of years past may not even be reviewed by an environmental manager or the public because it is considered outdated. Thus, the indicators program needs to develop a communication plan to ensure that information flows easily within the program and that data can be used by others outside of the program.

MONITORING PLAN IMPLEMENTATION

As previously noted, once the indicators have been selected and a monitoring plan developed, the program needs to be implemented. In some instances, the monitoring is already being conducted under other programs and the data only needs to be collected and analyzed for their intended use. In other instances, the monitoring will need to begin in new areas or for new parameters. It is assumed that the developed monitoring plan specifies who will be monitoring which parameters and when. If it does not, then a plan should be developed. Some indicator plans may call for the collection of a number of new parameters. In these cases, depending on the funding available, a tiered approach to implementing the monitoring plans may need to be taken.

When developing a monitoring program, one important aspect is that, depending on how the indicators are selected, the indicator may or may not be monitored at that time and the program may or may not be able to afford to monitor all of the indicators at once.
A monitoring plan can still be written to include all of the indicators selected, but should point out that new indicators will be implemented as funding becomes available. A plan could also be developed to add sampling for one or more of the selected indicators to the monitoring program during each future year of sampling or at other specified times. This tiered approach can then be used to negotiate for additional funding from other programs and the state legislature.

Ongoing monitoring is essential to assess the health of ocean and coastal ecosystems and detect changes over time. More than any other measure, monitoring provides accountability for management actions (U.S. Commission on Ocean Policy, 2004).

> Ongoing monitoring is essential to assess the health of ocean and coastal ecosystems and detect changes over time.

DATA COLLECTION AND ANALYSIS PLANS

Within the monitoring plan and MOUs, statements should be included regarding how data will be collected and analyzed. Sometimes it is easy to collect and analyze the samples, but difficult to compile the final data in one place for analysis. These steps need to be part of the plan. Groups collecting data for indicators have used both centralized and distributed data locations successfully. The form selected depends on program needs, funding, and accessibility to the databases. Evaluation of secondary data is critical.

REPORTING OF INDICATOR FINDINGS

Accurate and appropriate reporting of indicator results and data is critical to justify the program and to ensure that it is credible. Moreover, data collected and analyzed, but not properly reported, are of no value to scientists, managers, regulators, or the public.

Early in the program planning process, each indicator and monitoring project should develop a plan for reporting and communicating findings that supports the program's objectives. The plan may include a range of documents that convey the project's activities, data, and findings. These can range from brochures and flyers for public dissemination and relatively simple data reports to comprehensive interpretive reports that focus on progress and convey information to management and scientists. The plan should clearly convey the purpose of the different reports and modes of communication, their focus and content, the timeframes for publication, and distribution mechanisms.

Reporting plans differ for each program, as project objectives and communications needs vary. Reports will generally need to be customized for different stakeholders (*e.g.*, scientists, managers, the public). It is important to get the information to the stakeholders in a format they can understand and that will be useful for their particular needs. Formats such as scientific reports, report cards, science meetings, and newspaper articles and news conferences have been used successfully in different estuary programs. Each estuary program should plan on including this broad range of documentation to report on its indicators and progress.

The audience for which the indicator reporting may be intended generally falls into three general categories.

- Public. Reporting to the public requires information to be presented in a concise, public-friendly format with less technical content and with straightforward presentations. The objective is generally to keep the public informed, to conduct public relations, and to generate support for management activities.
  Examples of Reporting to the Public
  - "State-of-the-Bay" report
  - Report cards
  - Flyers
  - Newspaper articles
  - Web site

Long Island Sound Study—Reporting to the Public

"Mark Tedesco felt that the process of putting together a report that was primarily directed at the public was actually quite healthy for the project as it forced the developers to clearly and concisely describe the trends they had uncovered, and to draw some conclusions that could be easily presented." (Pidot, 2003)

Casco Bay Estuary Partnership—Reporting to Management

"Since many decision makers will often not read lengthy documents, it is essential, according to Diane Gould, to have a summary highlighting the report results and detailing their significance directed specifically at policy makers and managers. (Pidot, 2003)

Great Lakes Program—Reporting Status and Trajectories

"The assessment for each indicator…provide both a 'status' component (Good, Fair, Poor, Mixed) and a 'trajectory' component (Improving, Unchanging, Deteriorating, Undetermined)." (SOLEC, 2004)

- Management/Regulators. Reporting to program management and environmental regulators generally includes providing both highly concise summaries and "light" technical reporting. The objective is generally to provide updates that directly relate to past management actions by assessing the progress and success of management activities, and to provide recommendations and justification for future management activities, along with supporting information and data.
  Example of Reporting to Management/Regulators
  - "State-of-the-Bay" report
  - Progress report
  - Report cards
  - Technical summaries

- Scientific Uses. Reporting for scientific use generally includes scientific, technical interpretive reports, which provide data that can be used by the scientific community for detailed analysis. The objective of these reports is to make data available and develop an in-depth understanding of the environmental conditions—an understanding which, in turn, may also be used for public and management reporting.
  Examples of Reporting for Scientific Uses
  - Comprehensive data reports
  - Interpretive reports, with data appendices
  - Web sites with databases
  - Peer-reviewed papers and publications

The following sections are intended to provide broad guidance on how to make program findings available and the level of detail that is appropriate in various reports. They are not intended to prescribe ways to write a specific type of technical report or other document, or how to summarize indicator information for the public. No format or approach fits all programs. Fortunately, many programs and organizations are already actively reporting results from their environmental studies. The reporting and communication from these other programs and organizations can serve as excellent examples of reporting that can be considered, and modified to meet the needs of a specific program Again, each program should have its own well-considered reporting plan, to address specific well-defined objectives of the program. Some programs will emphasize scientific reporting of the results, while other may be more heavily weighted towards informing the public and public outreach. In the aggregate, experience from many programs demonstrates that successful programs incorporate the full spectrum of reports and written materials for communication to scientists, managers/regulators, and the public. Regardless of report type, a process of conceptualizing, outlining, annotating, drafting and polishing each report should be practiced.

Reporting to the Public

There are many and varied examples of effective reports that convey the state of an estuary to the general public. Examples include the *State of the Bay* reports (Figure 12) by the CBEP (Casco Bay Estuary Partnership, 2005a) (http://www.cascobay.usm.maine.edu/SOTB.html); the Pulse of the Estuary reports by the San Francisco Estuary Institute (SFEI, 2005) (http://www.sfei.org/rmp/pulse/2005/RMP05_PulseoftheEstuary.pdf); and the State of Boston Harbor reports by the MWRA (2002) (http://www.mwra.state.ma.us/harbor/enquad/pdf/2002-09.pdf). These types of reports are useful for communicating to those in the public who are actively involved in issues related to the program and wish to receive more information than the general public. In many cases, these reports have helped define the key issues and been used to form the basis of more technically sophisticated reports to management and the scientific community.

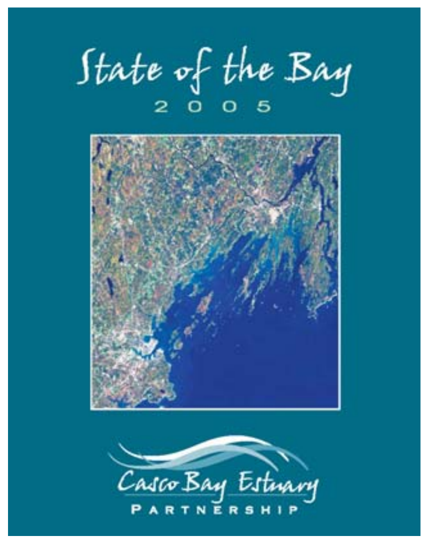


Figure 12. Casco Bay Estuary Partnership 2005 State of the Bay Report

Implementation

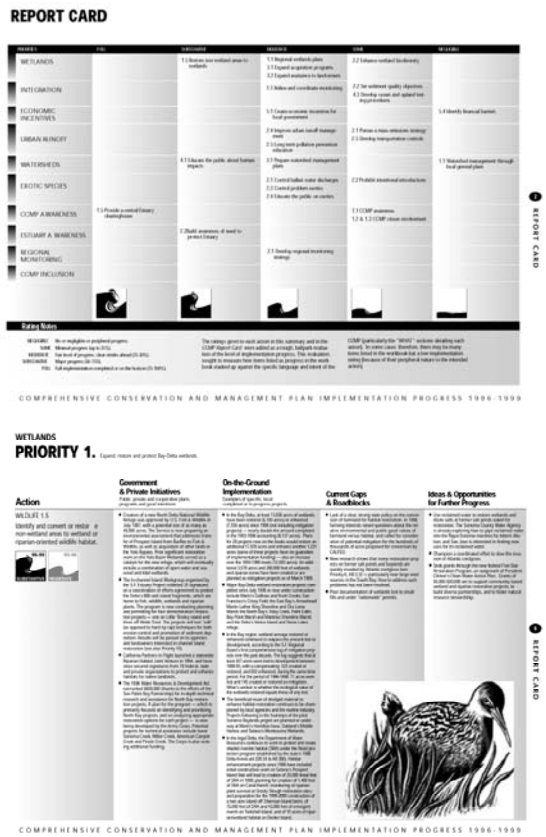


Figure 13. San Francisco Report Card 1996-1999

Report cards (San Francisco Estuary Project, 1999) (Figure 13) can be a valuable way to summarize program actions and related indicator responses. However, they can become tedious and carry the risk of oversimplification, which may result in misuse of the information presented. Thus, care must always be taken when simplifying information. Moreover, simplification must not happen at the expense of accuracy and should recognize the potential for misinterpretation. In addition to report cards, informational flyers can be highly effective in summarizing specific components of a program in a simple, eye-catching format that can reach a wide audience. Programmatic summaries (*e.g.*, annual updates) are also effectively communicated through concise flyers. Newspaper articles, news releases, and news briefings are other means of communicating to the public, as long as care is taken to ensure accurate representation of the information.

Finally, well-designed program web sites can be an excellent mode of communicating to the public, providing updates on activities, and providing an archive for access to historical documents. An example of an effective web site is the Chesapeake Bay Program's site (http://www.chesapeakebay.net/). Other examples include web sites by the MWRA (http://www.mwra.state.ma.us/), the St. Johns River Water Management District (http://sjr.state.fl.us/), the San Francisco Estuary Institute (http://www.sfei.org/), and the CBEP (http://www.cascobay.usm.maine.edu/).

Developing Public Materials. Primary among the challenges associated with developing public materials is ensuring accurate communication of information in a manner the general public can understand. The suggested writing level for these reports is at an 8th grade level reading ability.

Often estuary program staff are challenged to find creative ways to present information. When developing public materials, it is important to focus on answering those questions that are foremost on the public's mind in straightforward language and with concise images. Reports for the public should emphasize, but should not be limited to, addressing concerns around the "what and why" questions, and less on "who, when, and how." For example:

- Is the water safe to swim in or drink? What has improved or gotten worse? Why?
- Is the fish/shellfish safe to eat? If why not, what can be done about it?
- Have the changes that estuary programs have requested worked toward defined goals? For example,
  - Have fertilizer reductions and sewerage plant upgrades focused at reducing nutrient levels worked towards improving DO levels in the estuary?
  - When the dam was demolished, did the fish return upstream?
  - Have the rebuilt wetlands or open lands that have been conserved helped the estuary program in any way?
- What needs to happen next to improve the estuary? How can the public help (besides providing more money)?

While many in the public primarily are interested in whether the financial investment and effort they have put in to save the estuary has merit, some will want more in-depth reports. They often want to know that there is a plan to move forward.

Suggested forms for public reports have been conveyed previously. How that information is communicated also must be carefully considered. Any graphs used should be simple and easy to follow. Simple one-dimensional bar or line graphs seem to be the best at showing changes over time. Limited and carefully prepared information on statistical considerations can be effective (*i.e.*, indicating a trend is statistically significant rather than a detailed explanation of the statistical methods). Pictures, diagrams, and artist renditions are also helpful in documents prepared for the general public (and also for more technically enlightened audiences), especially when describing various estuarine species and habitat restoration projects. Text should describe the problem's past history, the current situation, and the required actions to be taken to reach the "optimal" or a desired end. If the project is long-term, developing mid-progress milestones that can be celebrated will help maintain public interest and involvement.

Questions invariably arise on how to best handle questions from the news media. Depending on the circumstances of the interaction, but especially for formal press briefings or news releases, information sheets should be prepared in advance and should include details on the information being conveyed. This will help ensure that journalists have the correct numbers and other pertinent information, rather than having them rely solely on their notes.

Reporting to Management/Regulators

Different types of state-of-the-bay and state-of-the-estuary reports are often excellent guides for developing written and oral reports to management/regulators (Casco Bay Estuary Partnership, 2005a; SFEI, 2005; MWRA, 2002), and may by themselves be effective for communicating information. In contrast to reports for public consumption, reports prepared for management/regulators often include recommendations and require technical and other justifications to support these recommendations. The reports prepared for managers generally have more detail and content than public reports and support the more public-oriented reports. The level of detail provided in management reports will also vary, depending on the managers'/regulators' oversight responsibility. One example of such a report is the *5 Year Progress Report: 2000-2004*, prepared by MWRA for the governor and legislature of Massachusetts (MWRA, 2006) (Figure 14). Report cards (see Figure 13) can be valuable for providing summary-level information to management/regulators but have the same limitations and risks associated with disseminating such materials to the public.

Figure 14. MWRA 5 Year Progress Report 2000-2004

Developing Management-/Regulator-Focused Reports. Management/regulator-focused reports address similar questions as those raised in public reports. They tend to provide more details and supporting information and focus on answering questions regarding whether environmental conditions or responses conform with an agency's mission or goals or a manager's oversight function. Reports for managers/regulators should address "what, when, where, and why" concerns and also address the "how" (either measurement, interpretive, or environmental) issues pertinent to the program's objectives. Depending on the specifics of the program, consideration of "who" (*e.g.*, responsible parties, ecological entities) may come into play. This means there normally needs to be an accounting of objectives as they relate to the agency's overall goals, the tasks that have been completed or started to date, the amount of funding that has gone toward these effort, and the status toward reaching the final goal. For estuaries within the NEP, this may mean linking progress made over a certain timeframe back to the specific goals outlined in the CCMP.

Reporting to the Scientific Community

The different types of state-of-the-bay and state-of-the-estuary reports can also be an excellent resource for the scientific community, and often form the basis for further in-depth analysis. Conversely, in-depth scientific reports and peer-reviewed papers often validate the content of the higher-level interpretive and synthesized reports prepared for managers and the public. Typically, the flow of reports is from detailed scientific reporting to the higher-level syntheses and integration at the management and public levels. Regardless, each of these audiences has influence over the content and direction of reports across the entire program.

Generally, science-based interpretive reports provide the details of the monitoring, research, and assessments that take place within the program. While there are no standard formats for interpretive reports, each should include a section that introduces the report's subject and objective(s), describes the method(s) used to collect and analyze the data, presents the results and findings, discusses the results, and develops conclusions. A concise executive summary is a valuable tool for these reports, as they help inform managers and the interested public. Depending on the project, the reports should incorporate recommendations regarding changes to the project/program and further studies. The level of detail in a report depends on where and how it will be published. An interpretive report often includes in-depth considerations, while a peer-reviewed paper provides a succinct presentation of the findings, with the degree of detail depending greatly on the publisher.

Interpretive reports are also developed with many different formats, including highly graphical and "reader-friendly" formats that, in many ways, are an expansion of a state-of-the-bay report. One good example of such a report is the "Baywatchers II" report, prepared by the Coalition for Buzzards Bay (Buzzards Bay Project National Estuary Program, 1999). Examples of technical reports with additional technical rigor include the *National Coastal Condition Report II* (EPA, 2005b), the *State of the Estuary: A Report on Conditions and Problems in the San Francisco/Sacramento-San Joaquin Delta Estuary* document (San Francisco Estuary Project, 2002), and the *Regional Monitoring Program (RMP) for Trace Substances* report (SFEI, 1999). Technical reports are particularly valuable for the rest of the scientific community when raw and summarized data are included as appendices. Well-designed program web sites can also be valuable to the scientific community, both in terms of being a repository for documents and also for housing and making available for general use data that may be accessed and downloaded by scientists.

Developing Scientific Community-Focused Reports. Unlike public- and management-focused reports, reports focused toward the scientific community are geared specifically toward reporting, interpreting, and synthesizing data in depth. These reports typically address in detail the "who, what, when, where, how, and why" questions. Scientists want to know everything, from the methods used to collect and analyze the samples, to how the data were treated for interpretation, to how the new data fit into scientific theories, hypotheses, and previously obtained data. These reports are normally highly technical, with figures and tables that support presentation of the findings, discussion, and conclusions. These reports are equally important as (some would say more important than) the public and management reports because they form the basis of future evaluations and conclusions regarding the overall condition, variability, and changes in the estuary. Reporting the actual data in these scientific reports is also crucial for future data comparisons. These reports often form the basis of peer-reviewed publications. Estuary programs should strive to ensure that reports prepared in support of their program maximize the development of information from the data collected.

Authors of scientific and technical reports that address environmental indicators should clearly communicate how the data from each selected indicator is linked to a specific outcome, represents broader environmental concerns, and supports decision-making. This documents how an indicator is useful to the estuary program and how it provides the necessary information to the program. If the authors and an indicator do not provide the necessary information, the link between the parameters and the interpretive results may result in estuaries spending unnecessary funds.

Report Data Quality/Timeliness

Inaccurate data and interpretation can lead estuary programs to make incorrect decisions based on those data or findings. It does not matter whether the report is for the public, management, regulatory, or scientific community, each report should be prepared carefully and should be based on accurate and complete data. An effective means of developing reports that meet program expectations is to have the authors develop an outline (preferably annotated) for each report in advance. Experience has also found that each report should be developed under a known level of data QA and interpretation verification (*e.g.*, peer review). To this end, technical, QA, and editorial reviews should be defined for each report and practiced by the estuary program.

It is also important that the reports be generated in a timeframe that will allow their findings/conclusions to be useful to management, regulators, and decision-makers. Data that is reported years after it has been collected can be useless if major changes are occurring within the estuary. Good practices are to have data available within 6 to 12 months of sample collection and interpretive reports completed within 1 year. An excellent example of the effective reporting schedules can be found under the MWRA Harbor and Outfall Monitoring Project, where data are required to be available within 3 months of collection and interpretive reports within 6 to 8 months of the end of the monitoring year. Such reporting enables implementation of preventative or corrective measures when a problem is just beginning to develop, not years later. Thus, it is important that estuary programs include in their reporting plans a schedule for reporting data. Another example of timely reporting is the 2006 draft Assessment Strategy developed for the Florida Everglades Restoration Monitoring and Assessment Plan. At a minimum, programs should provide data reports and preliminary findings at least every 2 years. This will provide the data needed for scientists to make decisions but will allow the program a little longer period (no more than every 5 years) to develop the larger programmatic or public reports.

The role of any report card, newsletter, management overview, or estuary data report developed is to make sure it conveys the intended message to the intended audience. A report that is useless to its audience will ultimately be useless to the estuary program that developed it.

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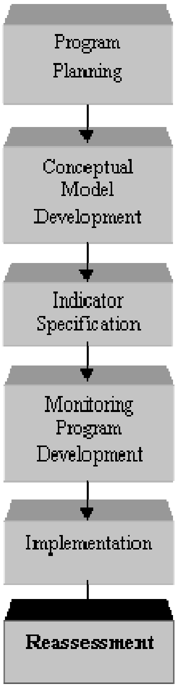
Implementation



INDICATOR REASSESSMENT

Most programs that develop a suite of indicators spend months, if not years, trying to select the most representative parameters and develop a robust monitoring program to support them. However, the process does not stop once the indicator measurement program is implemented. Continual assessment and reassessment of the performance of the program is the necessary next step. Reassessment of an indicator program ensures that the indicators are meeting expectations.

> It is important to reassess indicator programs a minimum of every 5 years to ensure that they are meeting expectations.

Reassessing an indicator program is not always a simple or clear-cut process. Some indicators answer specific questions (*e.g.*, monitoring DO levels to determine long-term increases/decreases in the water column or compliance with a state standard). Other indicators address the status of a broader question that cannot be easily answered (*e.g.*, monitoring catch of a species to estimate fish stock size). Even though an indicator was carefully selected, it is possible that it does not adequately address the question. For example, if a program is specifically concerned with metals inputs to sediment, a possible indicator may be to measure the amount of two or three key metals in the sediments of an area over time. If, after a period of time, the monitoring program finds that the concentration of metals in sediments is not changing as expected, concerns are raised as to why. In this case, the program needs to reassess the appropriateness of the metals monitored or conduct additional studies to determine why expected changes did not occur. These could be related to uncertainty in loading, physical changes in the sediment, geochemical processes, or the inappropriate selection of the indicator metal. Thus, the program needs to reassess and should potentially select a different indicator to effectively track changes in metals input to the sediment.

Each program should develop a reassessment plan that is designed to review the usefulness of the selected indicators. The reassessment should be conducted at a least every 5 years to ensure that funds are being spent economically and indicators are answering the intended questions. The initial step in the reassessment process is to review the current issues of importance. This review should allow issues that have been addressed to be removed, concerns to be modified, and new issues to be added.

Galveston Bay NEP—Indicator Refinement

"By consensus, the [Galveston Bay Council] will determine the final official set of indicators to be used by GBEP for inclusion on reports and public outreach materials. This is not to say that further refinements will not take place in the future as better datasets are found, monitoring programs improve or expand, and advances in research are made." (GBEP, 2004)

The next step in the reassessment process is to evaluate the questions the program must answer. Previous questions should be examined to determine whether they have been answered. New issues should generate specific questions. For the issues and questions that are still relevant, the next step is to determine whether the corresponding indicators remain valid. If so, the program should confirm the adequacy of the monitoring plan. If, during the review process, issues and questions were added, or if an indicator was no longer valid, the program needs to develop indicators appropriate to the questions and revise the monitoring plan. The key to any program review is relevant and recent information on the issues and questions. This includes selecting a new parameter whose measurement may be more cost-effective, or revising a methodology to provide a better understanding of the issue. Using outdated information may result in incorrect choices for the most appropriate indicators. Finally, the last step in the reassessment process is to implement the indicator program and revised monitoring plan.